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Habitat differences in the food composition of the wasp-like spider *Argiope bruennichi* (Scop.) (Aranei : Araneidae) in Poland

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ABSTRACT. During the last few decades the wasp-like spider *Argiope bruennichi* Scopoli, 1772 expanded its wide geographical distribution in Europe. In this paper we describe and test differences in the diet composition of the wasp-like spider inhabiting a river valley (traditional habitat) and xerothermic grassland (new habitat) in Poland. From a total of 163 webs of *A. bruennichi*, 430 prey items were found, mainly insects : Coleoptera, Diptera, Homoptera, Heteroptera, Hymenoptera, Lepidoptera, Mecoptera, Odonata, Orthoptera and Neuroptera. Moreover, a semi digested specimen of the common frog *Rana temporaria* was recorded. Habitats differed significantly in the percentage distribution of eleven general food categories. Among potential influencing factors the number of caught prey was correlated only with the height of the web hub above the ground. The wasp-like spider is ecologically flexible in the use of novel food spectra and this probably allows the colonisation of new localities, as well as habitats.

KEY WORDS : *Argiope bruennichi*, diet, prey selection, web structure, frogs.

INTRODUCTION

Amongst orb-weaving spiders the wasp-like spider *Argiope bruennichi* Scopoli, 1772 expanded its geographical range to northern parts of Europe. The range of the wasp-like spider was previously limited to south-east Europe (POETZSCH, 1963 BARABASZ & GÓRZ, 1998). However, during the last few decades the species has colonized many new sites in Belgium, France, The Netherlands, Poland, Denmark, Sweden and even Great Britain (GUTTMANN, 1979; JONSSON & WILANDER, 1999; MOYES, 1997; SCHARFF & LANGEMARK, 1997). The most important factors causing rapid geographical expansion of the wasp-like spider are : climate change, especially the increase in numbers of sunny and dry days in summer, floods of large rivers in Europe, as well as the establishment of large open habitats due to deforestation and drainage (DZIABASZEWSKI, 1959; GUTTMANN, 1979; HELSDINGEN, 1982; PUTS, 1989; WEICKMANN & GROBMEIER, 1997; SCHARFF & LANGEMARK, 1997; LINDEN, 2000).

Similar to other orb-weaving spiders, *A. bruennichi* is a generalist predator (RIECHERT & ŁUCZAK, 1982; RIECHERT & HARP, 1987; MALT et al., 1990; FASOLA, 1999). However, many studies showed that orthopterous insects and dragonflies were the main prey of the spider (URBAŃSKI, 1948; BEDNARZ, 1966; NYFFELER & BENZ, 1978; BARABASZ & GÓRZ, 1998). Moreover, CONRAD & BREINL (1992) even indicated a strong dependence between rich orthopteran fauna and distribution of *A. bruennichi* and linked the geographical range of the wasp-like spider with orthopteran abundance, as potential food supply. On the other hand, some authors showed that other prey, such as dipterans, hemipterans (mainly aphids) and hymenopterans constituted an important part of the wasp-like spider diet (NYFFELER & BENZ, 1982; MALT et al., 1990). However, in publications on wasp-like spider diet only a simple description of food content is given, without linking it to habitat, potential food sources, or web structure.

Therefore, in this study we focused on (1) a description of the wasp-like spider's diet composition in two different habitats in Poland; (2) analyses of differences in prey caught in both habitats; (3) some factors affecting hunting success connected especially with web structure (e.g. stabilimenta). We discuss our findings in the light of colonisation of new areas (*sensu* localities, as well as habitats) in Poland (particularly) and in Europe (generally).

MATERIAL AND METHODS

Studies were carried out during August 1999 in the Wielkopolska province, western Poland (52º N, 16º E). The study area covers two different habitats : wetland in the Warta river valley, near the village of Wrąbczykowskie Holendry (Pyzdry region) and small marginal grassland habitats (arable fields), near the villages : Powodowo, Obra, Daszewice (Wolsztyn and Poznań regions). The density of wasp-like spiders in both habitats is similar, ca 0.3 orb-webs/1m^2.

The spider webs were monitored before noon, mainly 9-11 a.m. The geographical exposition was measured based on the axis of the web elevation to the ground level. To ensure that chosen prey items of *A. bruennichi* were sampled, only wrapped preys were removed from webs and stored in tubes with ethyl alcohol (70%). To explain silk details (stabilimenta and turns on stabilimenta) on webs, Fig. 1 was supplied. Because we did not control all parameters for all webs, sample size is different in various analyses. Standard statistical methods were used to describe and analyse the data (Zar, 1999). All statistical tests were two-tailed. We considered $P < 0.05$ as the minimum acceptable level of significance.

RESULTS

Prey structure

Sampling a total of 163 webs of *A. bruennichi* revealed 430 prey items (mean ± SD = 2.6 ± 1.3 prey/web). In the webs, insects from the following ten orders were represented : Coleoptera, Diptera, Homoptera, Heteroptera, Hymenoptera, Lepidoptera, Mecoptera, Odonata, Orthoptera and Neuroptera. The most numerous species caught in the webs were : Blue-tailed Damselfly *Ischnura elegans* (Van der Linden, 1832) and a squash bug *Coreus marginatus* (Linnaeus, 1758). Moreover, in one web an eleventh category, one semidigested specimen of the common frog *Rana temporaria* (Linnaeus, 1758), was found.

Dragonflies and dipterans contributed over 62% of the total prey captures - Table I.

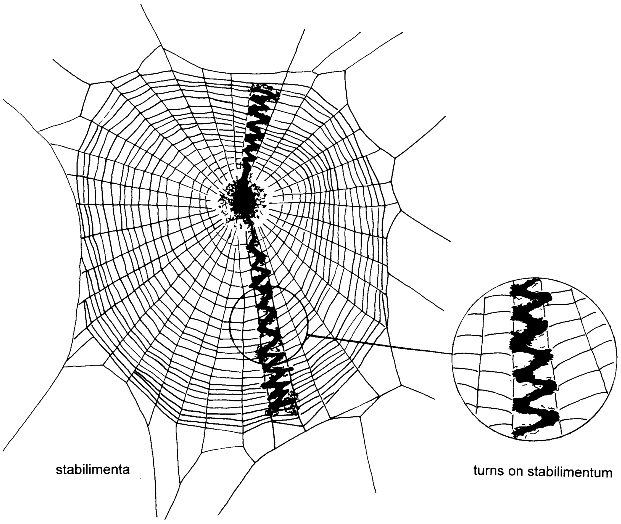

Fig. 1. – Web structure of *A. bruennichi*.

TABLE I

Composition of prey capture species in two different habitats.
Explanations: RV – river valley, XH – xerothermic habitats

Order	Family	Prey items	RV	XH
Coleoptera	Chrysomelidae	*Agelastica alni* (Linnaeus, 1758)	1	
		Cassida vittata Villers, 1789	3	
		Cassida viridis Linnaeus, 1758	1	
		Gastrophysa polygoni (Linnaeus, 1758)		4
		Phyllotreta sp.		2
	Coccinellidae	*Coccinella septempunctata* Linnaeus, 1758	2	
		Tytthaspis sedecimpunctata (Linnaeus, 1761)		2
		Propylea quatuordecimpunctata (Linnaeus, 1758)		1
	Geotrupidae	*Anoplotrupes stercorosus* (Hartmann, 1791)	1	
	Cetoniidae	*Protaetia cuprea* (Fabricius, 1775)	1	
	Staphylinidae		1	
	Phalacridae			1
	Latridiidae			8
Diptera	Bibionidae		1	
	Chironomidae		2	
	Culicidae		3	
	Syrphidae		1	
	other		10	104
Homoptera	Cercopidae		3	30
Heteroptera	Coreidae	*Coreus marginatus* (Linnaeus, 1758)	20	
	Miridae		3	
	Nabidae		1	
	Pentatomidae		6	
	Scutellaridae	*Eurygaster* sp.	3	
	other			26
Hymenoptera	Apoidea		7	
	Argidae		1	
	Formicidae		1	
	other		2	8
Lepidoptera	Pyralidae	*Pleuroptya ruralis* (Scopoli, 1763)		6
	other			11
Mecoptera	Panorpidae	*Panorpa communis* Linnaeus, 1758	4	
Odonata	Coenagrionidae	*Ischnura elegans* (Van der Linden, 1823)	134	
	Libellulidae	*Sympetrum sanguineum* Müller, 1764	5	
	other			6
Orthoptera	Tetrigidae	*Tetrix subulata* (Linnaeus, 1758)	1	
	Tettigoniidae	*Metrioptera roeselii* (Hagenbach, 1822)	1	
Neuroptera	Chrysopidae			1
Anura	Ranidae	*Rana temporaria* (Linnaeus, 1758)	1	

Web site / web attachment substrate

Webs of the wasp-like spider were located on 20 plants. The spider spun their webs most commonly on grasses (Poaceae) and nettle *Urtica dioica* (Urticaceae). We found significant differences in plant species composition used by spiders for web building in the two habitats (Table II, chi-square = 63.0, df = 9, $P < 0.0001$, calculated only for plant taxa with over 5 spider webs). In the river valley Poaceae, *Gallium* and *Urtica* were used more commonly, whereas in xerothermic grassland : Poaceae, *Oenanthe* and *Carex* were used (Table II).

TABLE II

Plants used as a basis for web in two habitats
in western Poland. Explanations – see TABLE I.

Plant	RV		XH		total	
	N	%	N	%	N	%
Achillea	3	2.34			3	1.76
Alnus	4	3.13			4	2.35
Carex	2	1.56	6	14.29	8	4.71
Cirsium	8	6.25			8	4.71
Equisetum	3	2.34			3	1.76
Frangula	5	3.91			5	2.94
Galium	14	10.94			14	8.24
Poacea	27	21.09	21	50.00	48	28.24
Juncus	6	4.69			6	3.53
Lamium	1	0.78			1	0.59
Mentha	8	6.25	4	9.52	12	7.06
Oenanthe		0.00	9	21.43	9	5.29
Plantago	1	0.78			1	0.59
Potentilla	6	4.69			6	3.53
Rhamnus	2	1.56			2	1.18
Rubus	4	3.13			4	2.35
Rumex	1	0.78	2	4.76	3	1.76
Umbelliferae	2	1.56			2	1.18
Urtica	24	18.75			24	14.12
Vicia	7	5.47			7	4.12
No. of plant	19		5		20	

Differences in diet composition between habitats

We found significant differences in diet composition between the habitats (Table I; Fig. 1). In the river valley a higher percentage of dragonflies (63.2%), and lower percentage of dipterans (7.7%) and homopterans (1.4%) and a lack of lepidopterans in the wasp-like spider diet were found. However, in xerothermic grassland the food spectrum consisted of dipterans (49.5%) and hemipterans (26.7%). Habitats differed significantly in the percentage distribution of the eleven general food categories (chi-square = 233.1, df = 10, $P < 0.0001$).

Factors affecting prey capture

We found no significant relation between the number of prey in the webs and direction of the web geographical exposition (Kruskal-Wallis ANOVA, $H_{8,\,40} = 9.508$, $P = 0.301$). The webs (hubs) were on average (± SD) 54.4 ± 16.0 cm above ground level (range 15-85 cm, n = 40). The number of caught prey was correlated with height of the web hub above ground level (Fig. 2, Spearman rank correlation, $r_s = 0.315$, $n = 40$, $P = 0.048$).

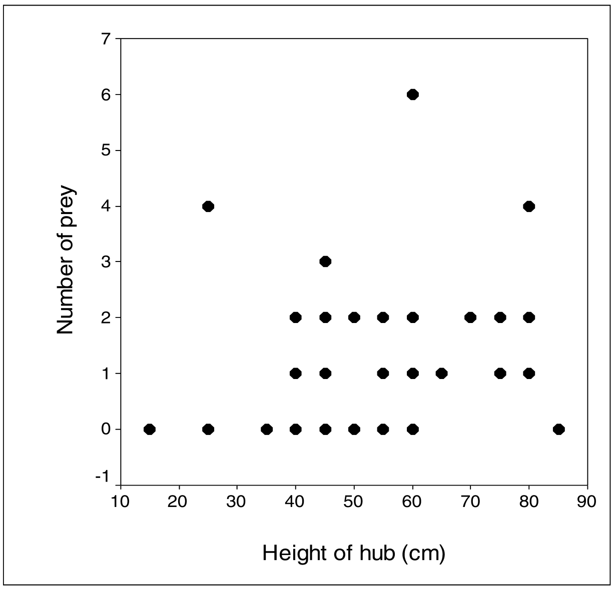

Fig. 2. – Relationship between height of web hub above ground and number of prey caught by the wasp-like spider.
Data for both habitats were pooled.

Relationships between the number of prey and web structure

Altogether 40 webs were taken for analysis from both habitats. There were 12.5% of webs with no stabilimentum, 62.5% of webs with one stabilimentum and 25% of webs with two stabilimenta (mean ± SD : 1.13 ± 0.61). Concerning turns on stabilimentum we found the highest frequency of six turns (17.5%) among analysed webs with such decorations (mean ± SD : 7.2 ± 4.6). There was no significant correlation between the number of captured prey and the number of stabilimenta on the web (Spearman rank correlation $r_s = -0.091$, $n = 40$, $P = 0.578$), nor between the number of captured prey and the number of turns on stabilimentum (Spearman rank correlation $r_s = -0.017$, $n = 40$, $P = 0.917$). The webs with different number of stabilimenta did not differ significantly in height above ground level (ANOVA, $F_{2,37} = 2.237$, $P = 0.112$).

DISCUSSION

The food of web building spiders, including *A. bruennichi*, is mainly selectively filtered from the air (NENTWIG, 1987). However, the wasp-like spider traps in the web both small sized insects (dipterans or aphids) as well as larger ones living on plants and/or the ground (grasshoppers or beetles). However, large sized insects even with a lower percentage among prey items can play an important role in providing food biomass for the orb-weavers (HOWELL & ELLENDER, 1984). The composition of the diet of orb-weavers included mainly the groups such as Homoptera and Diptera (NENTWIG, 1987). *Argiope bruennichi* was known, especially in earlier publications, as a species that specialised in catching large sized invertebrates, mainly grasshoppers (URBAŃSKI, 1948; CROME & CROME, 1961; POETZSCH, 1963; BEDNARZ, 1966; Pfletschinger, 1976). Our findings (a small (0.5%) proportion of orthopteran prey items) suggest that especially in newly occupied habitats, the wasp-like spider could explore a new diet spectrum of Diptera and Hemipterans. Nyffeler & Benz (1978), obtained similar results during a study of prey selection of the wasp-like spider on fallow land near Zurich (Switzerland). This suggests that the trapping of small prey is a possible adaptation to new habitats where much larger food items, e.g. grasshoppers and dragonflies are strongly limited. Although the wasp-like spider is behaviourally adapted (Pasquet & Leborgne, 1990, 1998) to catch orthopterans, the choice of smaller prey is an advantage to expand geographical distribution to the North (Indykiewicz et al., 1995; Barabasz & Górz, 1998), as well as to occupy new habitats : small patches of xerothermic grassland in intensively used farmland, or even arable field (Barabasz & Górz, 1998; Cichocki, 1998; and our unpublished data).

Moreover, an additional adaptation to the occupation of a new habitat is a change of plant species used as substrate for silk attachment. For a congeneric species, *Argiope aurantia* Lucas, 1833, McReynolds (2000) found that webs on grasses were more effective in trapping orthopteran prey than those established on herbs and composites. However, we did not test this relationship directly; we can only suggest that the use of a wide range of plants in new habitats improved possibilities of catching novel prey sources.

An important factor improving spider foraging strategy is web structure, especially conspicuous silk structures called stabilimenta (Herberstein et al., 2000). It is suggested that increased number of stabilimenta can attract prey to the web (Starks, 2002). Herberstein (2000), in a study of *Argiope keyserlingi* Karsch 1878, showed that webs with more stabilimenta caught more prey than webs carrying fewer decorations. However, this author did not find a relation between web height above ground and the rate of prey capture. Our findings are in contrast to this. The number of prey caught by the wasp-like spider was correlated with web (hub) height above ground level. We found that higher webs were more successful. Furthermore, we did not find an effect of the number of stabilimenta on the number of prey items in the web. Blackledge & Wenzel (1999), studying dipterans as prey, obtained interesting results and found that this group of airborne insects were less frequently caught in webs with stabilimenta than in those without stabilimenta. Wasp-like spiders feed mainly on tiny invertebrates on the northern part of their distribution and our results show that Odonata and Orthoptera were caught very seldom. Therefore, this is probably the reason why stabilimenta are not needed to catch most of such spider prey. Selection pressure should cause a significant decrease in the percentage of webs with those ornaments and it should be tested during a long-term study in the future.

We found also the capture and partly ingestion of a small specimen of the common frog by the wasp-like spider. It is, according to our knowledge, the first record of foraging on a vertebrate by *A. bruennichi* (Riechert & Łuczak, 1982; Riechert & Harp, 1987 and other cited literature). To fully understand the role of food in the colonisation of new localities and habitats this problem should be studied in detail, both by description of diet contents and by field experiments.

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